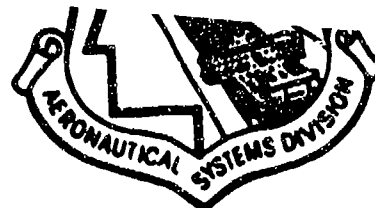
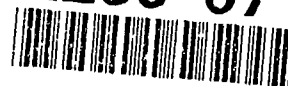


ASC-TR-93-5007

AN ENVIRONMENTAL STUDY OF THE
NATIONAL AEROSPACE PLANE

AD-A266 071



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WRIGHT-PATTERSON AFB, OH 45433-6503

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FINAL REPORT FOR 12/01/91-12/30/92

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13. ABSTRACT (Maximum 200 words) THE OVERALL OBJECTIVE OF THE UNITED STATES (US) NATIONAL AERO-SPACE PLANE (NASP) PROGRAM IS TO DEVELOP HYPERSONIC TECHNOLOGIES REQUIRED FOR FUTURE MILITARY AND CIVILIAN AEROSPACE PLANE SYSTEMS TO REDUCE PAYLOAD ;COST TO ORBIT AND PROVIDE FOR FLEXIBLE RESPONSIVE SPACE OPERATIONS. IF SUCCESSFUL, THE NASP PROGRAM WILL BE THE STIMULUS FOR DEVELOPING A WHOLE NEW CLASS OF AIRBREATHING HYPERSONIC AIRCRAFT POWERED BY CLEAN-BURNING SCRAMJET ENGINES USING LIQUID HYDROGEN AS THE PRIMARY FUEL. AS PART OF THIS DEVELOPMENT, THE POTENTIAL TO CAUSE ENVIRONMENTAL IMPACTS FROM THESE TYPE OF VEHICLES MUST BE CONSIDERED AND ANALYZED. THIS PRECESS HAS BEEN INITAIATED USING THE NASP PROGRAM'S PROPOSED X-30 FLIGHT RESEARCH VEHICLE AND FLIGHT TEST PROGRAM AS A BASIS FOR ANALYSIS. ENVIRONMENTAL ISSUES ADDRESSED INCLUDE NOISE ;AND SONIC BOOMS, STRATOSPHERIC OZONE DEPLETION, PUBLIC HEALTH AND SAFETY, HAZARDOUS MATERIALS/WASTE, AIR QUALITY, BIOLOGICAL AND CULTURAL RESOURCES, GEOLOGY AND SOILS, AND WATER USE. ALTHOUGH THIS STUDY IS NOT YET COMPLETE, PRELIMINARY ANALYSIS ;HAS DETERMINED THAT ;THE X-30 VEHICLE ;AND FLIGHTTEST PROGRAM WOULD HAVE MINIMAL ENVIRONMENTAL IMPACT.				
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AN ENVIRONMENTAL STUDY OF THE NATIONAL AERO-SPACE PLANE

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ABSTRACT

The overall objective of the United States (US) National Aero-Space Plane (NASP) Program is to develop hypersonic technologies required for future military and civilian aerospace plane systems to reduce payload cost to orbit and provide for flexible-responsive space operations. If successful, the NASP Program will be the stimulus for developing a whole new class of airbreathing hypersonic aircraft powered by clean-burning scramjet engines using liquid hydrogen as the primary fuel. As part of this development, the potential to cause environmental impacts from these type of vehicles must be considered and analyzed. This process has been initiated using the NASP Program's proposed X-30 flight research vehicle and flight test program as a basis for analysis. Environmental issues addressed include noise and sonic booms, stratospheric ozone depletion, public health and safety, hazardous materials/waste, air quality, biological and cultural resources, geology and soils, and water use. Although this study is not yet complete, preliminary analysis has determined that the X-30 vehicle and flight test program would have minimal environmental impact.

INTRODUCTION

The NASP program has led to significant advances in technologies necessary for future aerospace vehicles. The approach and scope of the environmental impact studies for the program have been summarized in a previous AIAA report.¹ The current paper discusses the status and preliminary results of the environmental study of the proposed NASP flight test program.

The NASP program has undergone numerous

changes since development of the initial plan for the environmental analysis. These changes resulted largely from differences between anticipated and actual funding for recent years. Although not yet approved, serious consideration is being given to incorporating additional ground and subscale flight tests prior to the government making any decision to build and flight test the X-30. The exact content of this revised program will not be finalized and approved until early 1993. Because of the potential for programmatic changes, the NASP Program described below may not be executed as presented. It is included here to briefly describe the program which was used as the basis for this study.

The NASP Program Used in This Study

The NASP Program is a US national R&D effort to develop hypersonic technologies that include scramjet propulsion, high temperature materials, etc. Culmination of this effort is the design, assembly, and flight test of an experimental aircraft, designated as the X-30. The X-30 would be capable of hypersonic flight and demonstration of single-stage-to-orbit (SSTO), i.e., no expendable boosters.

The overall NASP Program has been divided into three major phases of activity. Phase 1, "Copper Canyon", consisted of paper studies and limited tests to demonstrate the feasibility of SSTO aircraft. Phase 2, "Technology Development and Conceptual Design," was started in 1986 and is still on-going. The results of Phase 2 will be used to decide whether to proceed to Phase 3, in which the X-30 would be designed, built, and tested. The environmental analysis described in this paper was performed to provide input into the decision on whether to proceed into Phase 3.

Part of the Phase 2 effort was the development of a draft Phase 3 program development plan, which was completed in November 1991 by the NASP national contractor team. This program plan described and integrated all the activities necessary to construct two X-30 aircraft and assumed initiation of Phase 3 in 1993 with a first flight goal in 1997.

X-30 Description

The X-30 would be a manned aircraft capable of horizontal takeoff and landing on conventional runways and would be designed to achieve orbital velocity (approximately Mach 25). The X-30 conceptual design baselined the vehicle at approximately 150 to 200 feet in length with a takeoff gross weight of approximately 325,000 pounds. The X-30 would be a research vehicle for studying and understanding hypersonic flight in the tradition of other successful (X-series) experimental aircraft.

The X-30 would feature advanced technology: high-temperature, high-strength materials; ramjets; supersonic combustion ramjets (scramjets); and rockets. Cryogenic hydrogen fuel would be combusted with atmospheric and liquid (on board) oxygen.

Phase 3 Summary

A 1991 program development plan describes the details involved with flight testing the X-30. The flight test program would consist of up to 150 flights, using an incremental envelope expansion process and proceeding to an orbital flight. A maximum of four flights per month would be flown over a five-year period; most of the 150 flights would be atmospheric (to study various aspects of hypersonic flight). Initial flights would be at lower altitudes, within restricted airspace; later flights at higher Mach numbers would be flown above 60,000 feet altitude across the conterminous United States. Demonstration of SSTD capability would take place after the performance of the vehicle and its safe operation were verified.

Assembly of two X-30 aircraft would occur at either U.S. Air Force Plant 42, in Palmdale, California, or Edwards AFB, near Lancaster, California. Support facilities would be constructed at one of several sites on Edwards AFB. Facility requirements include storage capacity for the cryogenic propellants, taxiways, engine runup pads, hangars, mission control centers, and associated support facilities. One support facility would be a slush-hydrogen production plant, which would be used to convert liquid hydrogen into a slush mixture of

liquid and solid hydrogen. Slush hydrogen could then be used as a propellant in higher Mach flights.

STATUS AND APPROACH OF STUDY

The public was first informed of the NASP Environmental Program in January 1991 when the Air Force Center for Environmental Excellence issued a Notice of Intent in the Federal Register and major newspapers in the Washington, DC and Edwards AFB areas. Public Scoping Meetings were held in February 1991 at Washington, DC and Lancaster, CA. At these meetings, the general public and news media were given a one-hour overview of the NASP Phase 3 Program followed by a public comment period.

The NASP Program is currently studying various changes to the 1991 program plan. The public will again have an opportunity to comment when the Joint Program Office publishes the draft Environmental Impact Statement on the revised program.

The NASP environmental analysis is conventional in that it uses the precedent of relevant programs, the guidance of legal requirements, and processes of scientific and engineering analyses. The unique technological factors associated with the NASP program do require some special analyses and criteria. The program is being advanced with the goal that the NASP program must be environmentally acceptable. The design process for the aircraft and ground support systems must ensure this goal is reached. The proposed Phase 3 Flight Test Program has undergone an environmental impact analysis process to study potential effects on the environment from the proposed action and alternatives. Initial analysis was prepared based on the 1991 program development plan. In relation to this plan, the environmental analyses have reached a reasonable level of maturity. However, some analyses were stopped prior to completion, and finalization of the environmental analysis has been postponed because of known program revisions. The potential environmental effects presented below are based on preliminary findings and require further analysis upon maturing the X-30 design.

AREAS OF INTEREST

The NASP Program has the potential to influence several environmental areas. These influences are discussed in the context of two major portions of the Flight Test Program: flight test activities and ground support activities.

Flight Test Activities

The primary areas of environmental interest for flight test activities are aircraft noise, sonic booms, air quality (primarily depletion of stratospheric ozone), and public health and safety.

Aircraft Noise

The X-30 would generate high noise levels during takeoff. However, based on maximum single event noise modeling (AL), the 80 decibel (dB) contour is generally smaller than for several existing military aircraft (e.g., B-1 and B-52). Because of the size of Edwards AFB, the 80 dB (AL) contours will be within the base boundary, and no off-base impacts are projected.

Modeling the X-30 takeoff using Day-Night Average Sound Level (DNL) noise levels indicates that the X-30 will cause negligible changes to existing and projected DNL contours at Edwards AFB. This results from the small number of X-30 operations compared with the total level of operations at Edwards AFB. The 65 dB DNL levels modeled with the X-30 do not extend off Edwards AFB.

Sonic Booms

Analyses to date for the potential impact of sonic booms have relied on a mixture of state-of-the-art technology and simplifying assumptions. Numerous existing studies on sonic booms have provided a data base for the current work. However, the vast majority of the existing data base is limited to less than Mach 3 and altitudes up to approximately 80,000 feet for vehicles in steady, level flight. Overpressures in the database ranged from about 1.5 to 3.0 psf, with very little useful data at overpressure below 1.0 psf for either subjective responses or structural effects. This meant both empiricism and estimation were significant factors in some sonic-boom analyses.

Sample NASP flight tracks were developed using the X-30 flight simulator at NASA Dryden Flight Research Facility on Edwards AFB. A total of 14 typical X-30 flight test missions were flown in the simulator for different speed regimes and flight paths across the United States. Representative flight paths were utilized for the X-30 sonic boom preliminary analyses and were not optimized for minimizing sonic signature effects. Sonic boom overpressures for this approach projected carpet-boom overpressures primarily in the 0.0 to 1.5 psf range. Overpressures for transition and turn focus booms were

calculated to be primarily in the 0.5 to 4.0 psf range, but in rare cases could range up to 10 psf.

The X-30 predicted carpet boom overpressures are in the same range as those from overflights of SR-71 "Blackbirds" and enroute descent of the Space Shuttle.^{2,3} Most of the supersonic operating areas in the United States are currently exposed to similar carpet and focus boom levels from fighter aircraft. Higher operational altitudes, atmospheric attenuation, and the decreased Mach cone grazing angle are factors in reducing X-30 overpressures to a level equal to, or less than those of conventional aircraft.

X-30 flight operations would expose portions of the US population to sonic boom effects. The number of people actually annoyed would be a subset of those exposed due to factors such as personal sensitivity, background noise, and site influences (indoors or outdoors). Potential impacts are a function of the land uses, types of wildlife, structures, and people exposed to X-30 sonic booms.

Annoyance was estimated based on historical data (i.e., complaint histories of SR-71 overflights). The SR-71 program experienced less than one annoyance or property damage complaint for every two flights, when flying over areas of low population.⁴ Similar rates of complaints may be expected for the X-30 program. Studies of empirical data indicate that X-30 levels of overpressures are likely to cause little to no damage.⁵ The highest overpressures modeled would occur within the supersonic operating areas in the vicinity of Edwards AFB. These supersonic operating areas are located over the sparsely populated Mohave Dessert, which are routinely exposed to sonic booms from other aircraft. Short term startle effects on wildlife are expected. Several studies have shown that some wildlife exposed to repeated sonic booms eventually become habituated, and no additional startle effects occur.^{6,7,8}

The NASP Flight Test Program will minimize the effects of sonic booms by avoiding noise sensitive receptors and time periods. The X-30 will fly during daylight hours and not on weekends. This will minimize sleep interference and disturbance to recreational and leisure type activities. The X-30 will always climb and descend subsonically when below 30,000 feet mean sea to eliminate generation and propagation of an acoustic signature during low level maneuvering flight. The X-30 flight track will also avoid directly overflying large population centers and other noise sensitive receptors.

Air Quality/Ozone Depletion

Estimates of X-30 engine emissions were determined at various speed and altitude regimes. A residual circulation model developed and utilized at NASA Goddard Space Flight Center used X-30 emission and representative flight profile data to estimate the amount of stratospheric ozone depletion. The results have shown, for the entire flight test program, a maximum local ozone depletion of 0.006 percent and maximum yearly average global total ozone depletion of 0.00009 percent. These changes are quite small and near the limits of the numerical accuracy of the method employed.

No numerically significant decrease in ozone was predicted for the upper atmosphere with the method and data set cited above. Compared to natural phenomena, such as results from volcanic eruptions, the calculated values are also essentially negligible. For comparative purposes, studies have estimated an average of 1.7 to 3.0 percent total ozone depletion from 1969-1986 over the conterminous United States.⁹

Public Health and Safety

As in similar studies, considerations for public health and safety focussed on the possibility of flight test accidents. Initial analyses of failure modes for the X-30 and other relevant experimental vehicles indicate the program should proceed with an incremental expansion of the flight envelope.

The NASP Program has included safety factors for design and operational parameters. The X-30 is being designed to safely operate with at least two discrete system failures and would return to base upon first sign of one major system failure. Early flights would be conducted in specially designated restricted airspace, where all flight activities are scheduled, eliminating in-flight conflicts with other aircraft. These early flights would also be in areas of low population density. All higher Mach number flights would be at altitudes above 60,000 feet where there are very few aircraft. Procedures are being developed to coordinate with other users of this high altitude airspace, including restricted airspace. Finally, the program is planning for the use of numerous contingency landing sites across the United States, that would be available for the X-30 in the event of an emergency. Although specific flight routes have not been determined, each mission would be planned based on location and availability of these contingency landing sites. These plans reduce the possibility and severity of emergency situations.

Ground Support Activities

Edwards AFB, California, has been identified as the primary support base for the NASP Flight Test Program. Based on site-specific analyses of various environmental resources, a number of potential issues were identified that relate to support facilities and operations for hypersonic aircraft. Rather than discuss specific impacts at Edwards AFB, this paper summarizes the types of impacts that could occur at any ground support site for cryogenic hydrogen-propelled hypersonic aircraft. Both construction of support facilities and operations are discussed.

Facility Construction

Based on program requirements for various support facilities, approximately 130 acres of land adjacent to an existing airfield facility may be impacted (if all new facilities are built). Explosive safety buffer zones (required by Air Force Regulation 127-100) may require over 400 acres of land dedicated to program use (i.e., no other programs can use the land within these zones while potentially explosive activities are occurring).

Depending on the site location for these facilities, construction could affect several environmental areas. These areas may include air quality, biological resources, cultural resources, and geology/soils.

Temporary generation of nuisance dust (particulate matter) and emissions from construction equipment may interfere with attainment of air quality standards in the local air basin, as regulated by the Clean Air Act.

Ground disturbance may impact native vegetation and wildlife; in particular, the potential presence of threatened and endangered species or sensitive habitats (e.g., wetlands) must be considered. Impacts may require special mitigation procedures (e.g., worker education programs, habitat replacement) and will be developed in coordination with the U.S. Fish and Wildlife Service and/or U.S. National Marine Fisheries Service.

Impacts to archaeological, historical, paleontological, or other cultural resources can occur because of ground disturbing activities. Some sites may have features that are potentially eligible for the National Register of Historic Places. Modification of existing facilities can also affect eligible historic places. Eligibility can cause additional requirements for mitigation, such as

documentation of historic significance, preservation and study of artifacts, worker education programs, etc.

Ground disturbing activities can cause geologic impacts such as soil erosion, loss of prime and unique farmlands, or loss of mineral/aggregate resources. In addition, regional seismic conditions may cause requirements for more stringent building code standards.

Based on the current status of the NASP environmental impact analysis at Edwards AFB, construction of facilities is expected to affect some of these resources, but the level of impact is expected to be generally low.

Ground Support Operations

Ground support facility operations also have some potential for environmental effects. Operations that may affect the environment include transportation of the large amounts of cryogenic propellants, storage and use of the cryogenic materials, engine testing, handling of hazardous materials, and generation of hazardous waste. Program personnel and associated operations will also create additional infrastructure demand. Environmental areas of interest include noise, biological resources, air quality, water use, and hazardous materials/waste.

The program would require large amounts of liquid hydrogen to use as a propellant. Based on conceptual design of the X-30, a 1.5 million gallon storage tank would be required, and up to 262 shipments by truck (or 110 shipments by railroad car) would be required monthly to supply the liquid hydrogen. Although there would be some risk associated with the transportation and storage of liquid hydrogen, the historical safety record reflects very few accidents. Advances in technology should provide further enhancements to safety.

Storage of large quantities of liquid hydrogen, production of slush hydrogen, and aircraft fuelling operations cause a need for a hydrogen flaring system. Development of this system has siting considerations and environmental implications. Hydrogen flaring produces an invisible flame and must be considered when designing the system and siting it near an operating airfield. Compliance with applicable airfield regulations would ensure no safety impacts. The flare could also have impacts to birds or other flying animals in the area. If the proposed site is a known habitat for threatened or endangered flying species, additional designs for protection may be required. However, local noise from

flaring operations may scare most animals away, which would reduce the likelihood of impact.

Engine testing would cause high local noise levels during run-up activities. Prudent siting of the facility, use of noise suppressing mitigation measures (e.g., blast walls or hush houses), and compliance with applicable Occupational Safety and Health Administration (OSHA) regulations would be used to minimize these impacts.

The X-30 is still in conceptual design and does not have a complete list of types and quantities of hazardous materials that would be used to build, operate, and maintain the aircraft. However, it is a stated program goal to minimize the use of hazardous materials on the program. Compliance with applicable use and disposal regulations should ensure minimal impact from these activities.

Indirect operational impacts could occur from an influx of program workers. Based on the 1991 program development plan, a maximum of 3,400 personnel could be dedicated to the NASP Program in a given year. These personnel would increase traffic (and therefore, air emissions), water use, power consumption, etc. in the vicinity of the construction and operational site(s). If any of these resources are near or at capacity, addition of demands for a new project could impact the resource. However, increasing the number of government and contract employees also represent jobs, which is an important consideration if the area either has few people or has a high unemployment rate.

POSITIVE ENVIRONMENTAL CONSIDERATIONS

The NASP Joint Program Office intends to reasonably minimize adverse environmental impacts while maximizing environmental benefits of the program. A number of environmental benefits of the NASP Program (and from follow-on NASP-derived aircraft) are discussed below:

The NASP Program has fostered interest and support within the hypersonic aircraft, spacecraft, hydrogen, and environmental communities. The program has established a national network of recognized experts and database which lays the foundation for future programs.

Liquid hydrogen is an attractive propellant source since it does not produce any aluminum, hydrochloric acid, or carbon dioxide exhaust products.

which are common pollutants of existing propellants.

Continued research into liquid hydrogen and oxygen propellants may lead to the development of alternative fuels for aircraft, automobiles, and other industries. These developments contribute to the transition away from fossil-fuel based national infrastructure and economy.

SSTO aircraft would not generate any ocean debris or pollution from external stages.

Computational fluid dynamic models that were developed for the NASP Program are already being applied to automobile engine design to improve fuel economy and reduce emissions.

The X-30 may be used for high altitude stratospheric research, much as the TR-2 is currently used today. The X-30 can serve as an environmental platform to study environmental effects of hypersonic aircraft. Ground based monitors would measure X-30 sonic signatures to increase scientists' understanding of sonic booms. X-30 propulsion emissions would also be measured to determine environmental characteristics of scramjet engines. Data gathered from the NASP program would serve as a baseline to forecast environmental impacts for future hypersonic programs.

ENVIRONMENTAL AND QUALITY MANAGEMENT

Success of an environmental program is greatly enhanced by establishing sound management principles from the start. Listed below are several key concepts the NASP Environmental Team employed to manage their technical, budgetary, and regulatory activities.

It is extremely important to obtain the country's top experts in the critical or controversial areas of environmental study. Having the best experts ensures the analysis is current, thorough, and defensible against others who may be challenging the analysis. If a member of the scientific community or general public is not satisfied with the technical approach or assumptions made, the effort or analysis may have to be reaccomplished. Taking a quality approach from the very beginning saves time, effort, and money.

Over the years, the amount of environmental regulation and requirements for supporting analysis has grown significantly. Early consultation with legal representation will ensure all necessary legal requirements

are met. Since program funds are usually limited, environmental lawyers can advise on where to focus scarce resources on different areas of environmental concern.

There are numerous local, regional, and federal agencies that can assist in the analysis process. Early consultation with these groups can help identify the important environmental issues, gather existing data, and refine the scope of the analysis to what is absolutely necessary.

Before conducting a new environmental analysis, consider alternatives and investigate if other programs have conducted similar studies. Many environmental areas have been previously studied by other programs and their results may be useful. The government also has a vast resource base that can be called upon, and its technical library database is second to none. The government has already conducted thousands of environmental studies and are readily available. Another alternative is to share environmental costs with others. If another program or commercial venture is looking for similar information, it may be cheaper to expand the effort to encompass everyone's requirements and share the costs.

SUMMARY

The NASP Program is a US national research and development effort to develop hypersonic technologies for future aerospace systems. The overall NASP Program has been divided into three major phases of activity. The third and final phase of the NASP Program would be when the X-30, an experimental research aircraft, is designed, built, and tested. The proposed X-30 Flight Test Program has undergone an environmental impact analysis process to study potential environment effects. Initial analysis was prepared based on a 1991 program development plan. In relation to this plan, the environmental analyses have reached a reasonable level of maturity. However, some analyses were stopped prior to completion. The environmental analysis has been temporarily postponed because the NASP program has undergone numerous changes since development of the 1991 program development plan. The environmental analysis will resume after developing a new program plan that clearly describes the future NASP program.

The scope of this study has remained the activities for construction of the NASP X-30, the ensuing flight tests and associated ground-support as described in

the 1991 program development plan. The environmental study assessed the potential effects of noise, sonic boom, air quality/emission, and public health and safety for the flight test; it also evaluated environmental factors for facility construction and ground-based operations. Although preliminary results have not identified any substantial environmental impacts, the environmental analysis will be continued, as required, to achieve full approval for NASP as being environmentally acceptable.

GENERAL CONCLUSIONS

The environmental study generally concludes that airbreathing hypersonic aircraft may cause some minimal level of environmental impact. Program goals and consideration of environmental conditions during facility siting, design, and program implementation will greatly minimize the level of potential impacts. On balance, many aspects of this new class of vehicles also have the potential for positive environmental considerations that must be pursued in future hypersonic aircraft programs.

Changes to the NASP Program may affect the final results of the analysis presented. However, although the results of these analyses are preliminary, they have value in understanding the types and relative amounts of impact from the NASP Flight Test Program analyzed. These data can then be used as a guide to chart environmental efforts for future hypersonic aircraft programs.

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**An Environmental
Study of
the National
Aero-Space Plane**

by:

**Maj Helmut Reda
Gregory T. Duecker**

December 3, 1992

Environmental Study National Aero-Space Plane

Outline

Introduction

Status of Environmental Study

SSTO X-30 program description

Areas of environmental interest

Positive environmental contributions

Management considerations

Future plans

Conclusion

Environmental Study National Aero-Space Plane

Introduction

- Hypersonic technologies are of international interest
- Environmental aspects of these technologies must be understood
- NASP program has been very pro-active in studying these aspects
- Although NASP program is changing, results are still useful to future environmental analysis of hypersonic vehicles/programs
- Following paper describes preliminary findings of NASP program sponsored environmental impact studies

Environmental Study National Aero-Space Plane

Introduction (Cont'd)

**Study Objective: Determine environmental acceptability of
X-30 flight test program**

**Approach: Analysis based on existing environmental
methodologies**

Program Requirement:

NASP flight test program must be environmentally acceptable

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Status of Environmental Study

Public scoping meetings

- Lancaster, CA February 26, 1991
- Washington D.C. February 28, 1991

Initial analysis virtually completed

Preliminary Draft EIS (PDEIS) completed

PDEIS in caretaker status pending:

- NASP preliminary design inputs
- NASP program changes

PDEIS to be revised following program refinements

NASP Environmental Analysis On Hold

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SSTO X-30 Program Description **Basis for PDEIS**

Phase 3 decision	1993
Build ground support system	1993-1996
Build and assemble two X-30's	1995-1998
Flight test at Edwards AFB	1997-2002
• Initial glide tests	1997
• First flight	1997
• SSTO flight	1999
• Last flight	2002
Total of 150 flights/maximum of 4 flights per month	

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X-30 Flight Test Operations Program

	Months into		Number of	Mach	Altitude
	Schedule	Misslons			Range (ft)
Envelope Expansion & Preparation for SSTO	0-6	12	0-3	0-85,000	
	7-10	16	3-6	60,000-105,000	
	11-16	24	6-12	70,000-110,000	
	17-23	27	12-17.5	95,000-135,000	
SSTO	24	1	25	400,000+	
Subtotal	80		(Low Earth orbit)		

An additional 70 hypersonic research tests would follow SSTO flight to expand the X-30 flight envelope

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Areas of Environmental Interest

Flight test operations

- Sonic booms
- Ozone depletion
- Public health and safety

Ground support operations (Generic Considerations)

- Ground disturbance
- Biological resources
- Cultural resources
- Air quality
- Geology and soils
- Water use
- Noise

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Flight Test Operations: Sonic Booms

Influenced by:

- Aircraft shape, speed, weight, trajectory, and flight path
- Location of noise sensitive receptors

Complex analysis

Requires further data on human response

Sonic boom footprints similar to Space Shuttle and SR-71 Blackbird

Modeled overpressures:

- Carpet booms
 - Typical focus booms
 - Rare focus booms
- 0.0 to 1.5 psf
0.5 to 4.0 psf
up to 10 psf**

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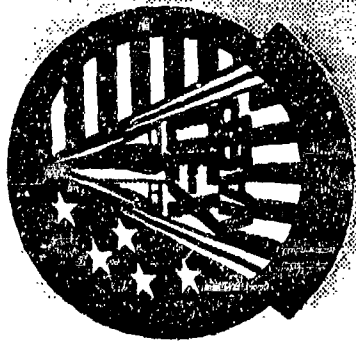
Flight Test Operations; Sonic Booms (Cont.)

Environmental studies conclude:

- Property Damage: Minimal impact
- Annoyance:
 - Minimal impact to general public
 - May interfere with Native American ceremonies
- Wildlife: Minimal impact
- Archaeological and historical sites: Minimal impact
- Avalanches or landslides: Minimal potential

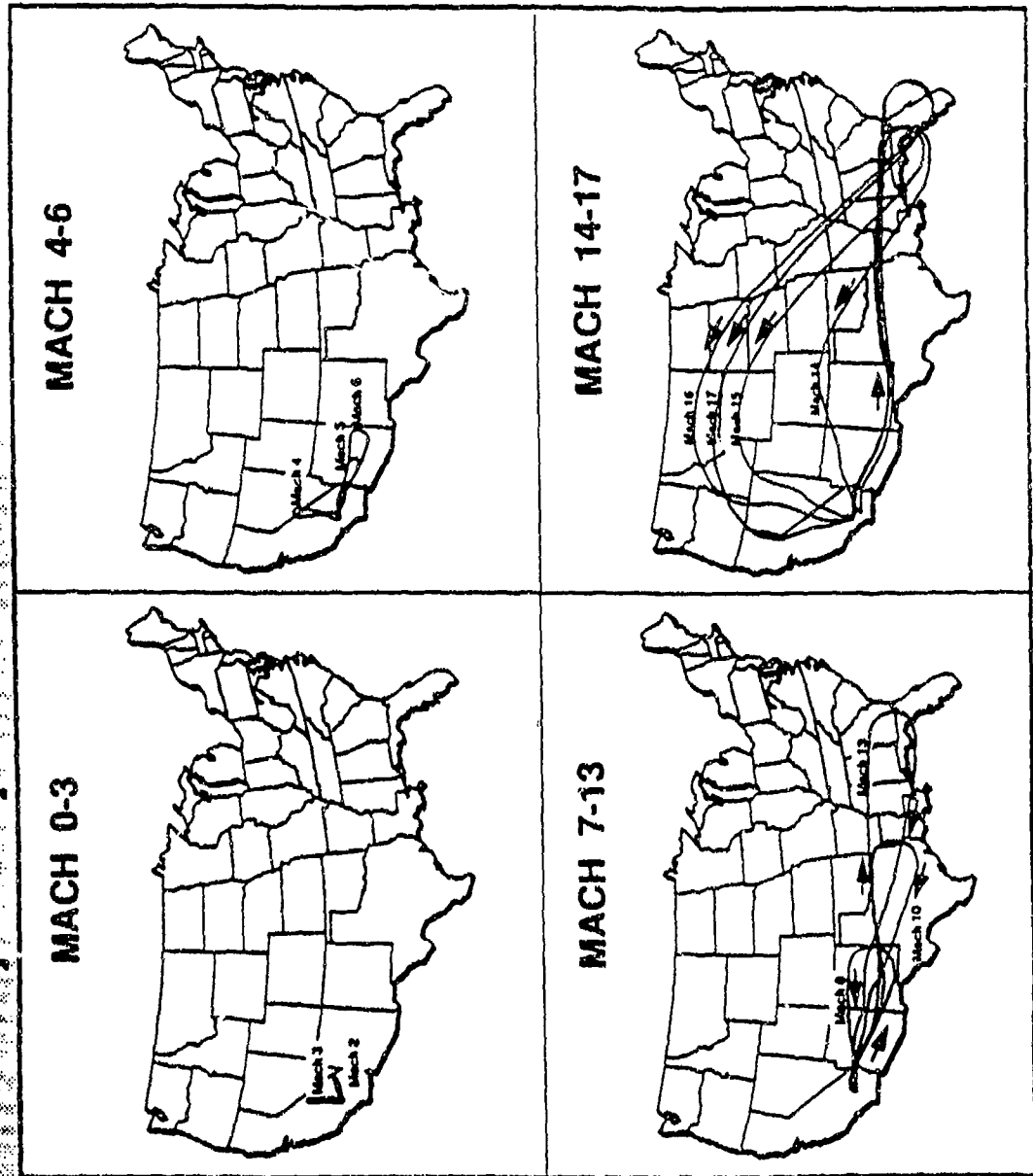
Mitigation measures can be implemented to reduce impacts

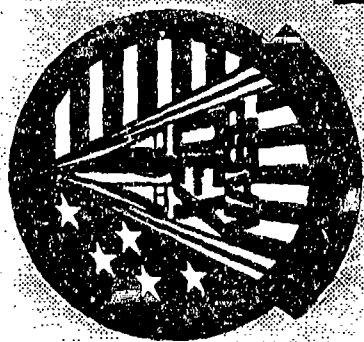
Minimal sonic boom impact



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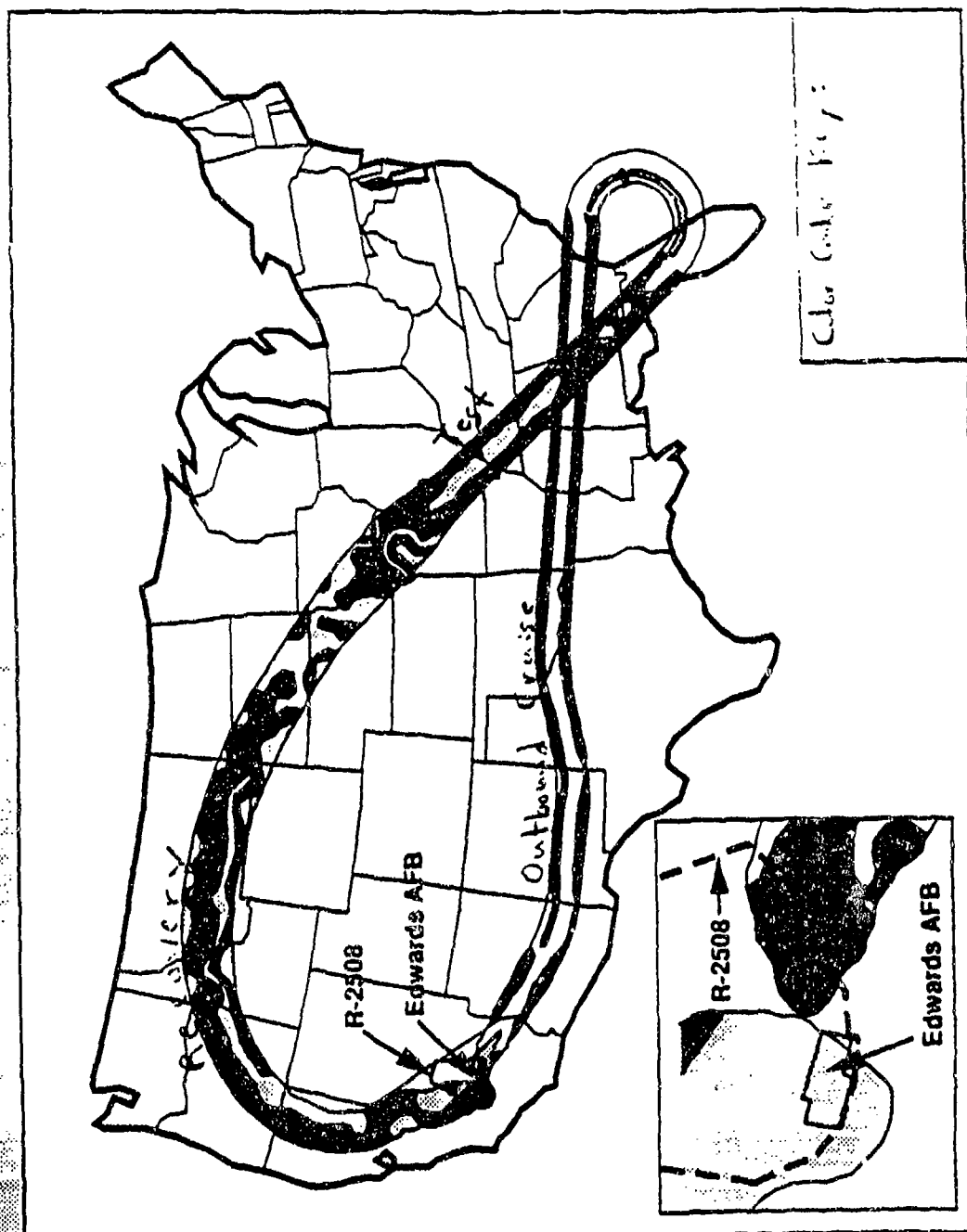
Typical Flight Tracks for X-30 Envelope Expansion over CONUS

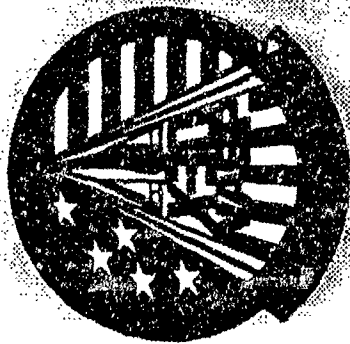




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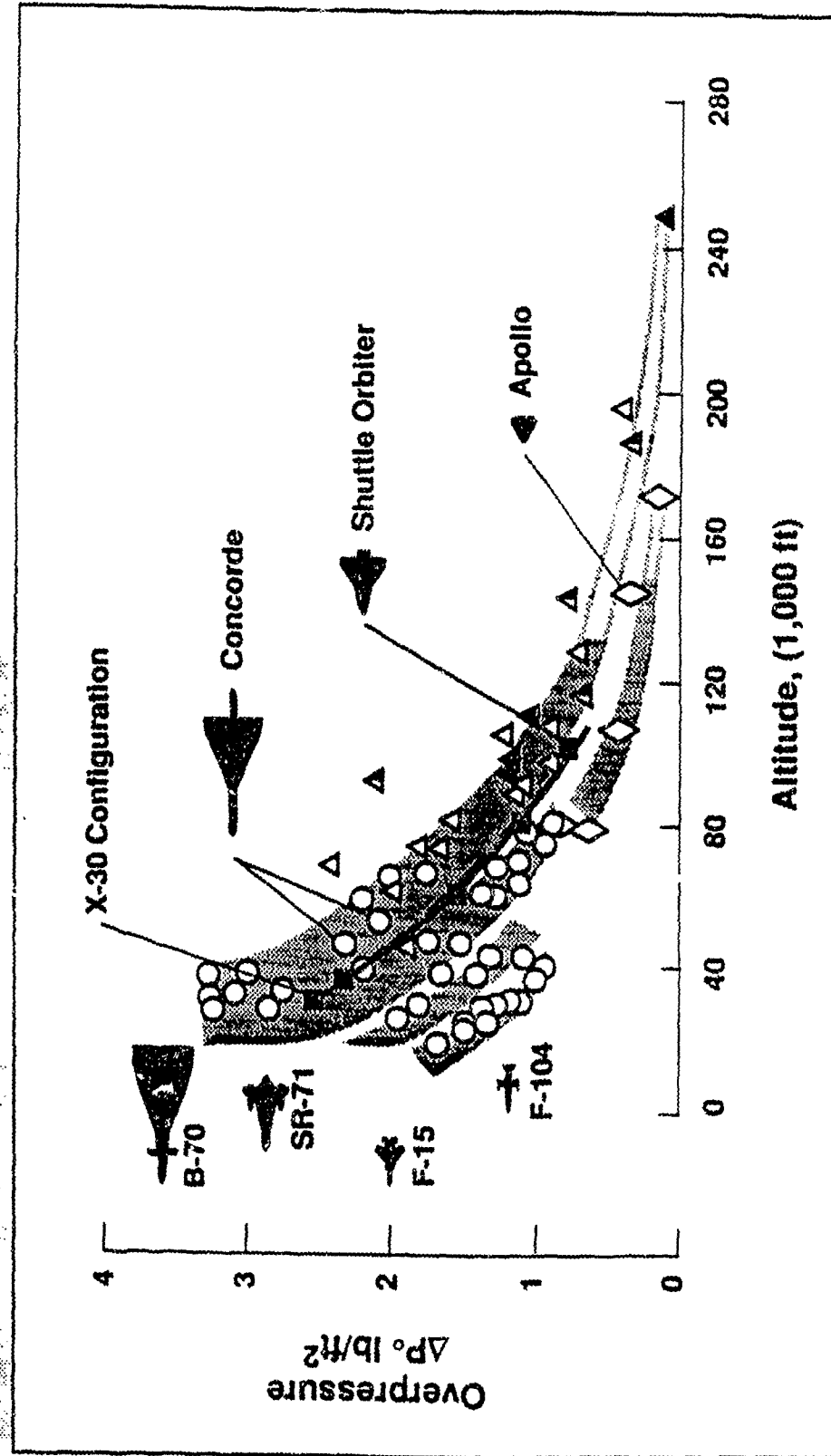
X-30 Mach 17 Sonic Boom Footprint



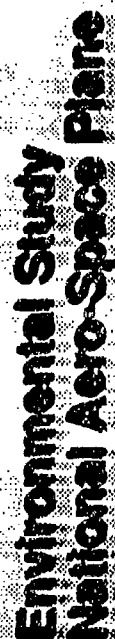


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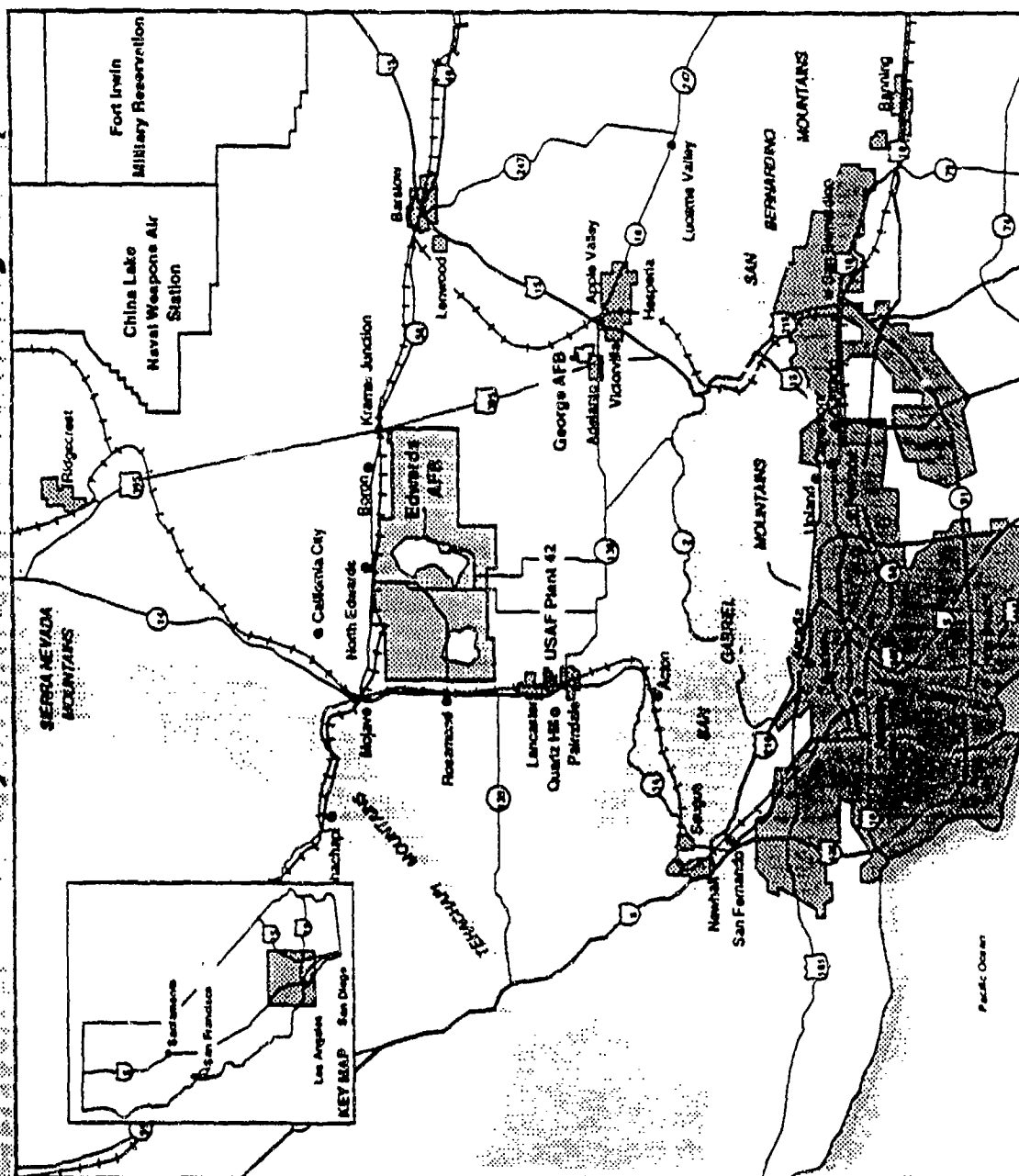
Summary of Boom Prediction

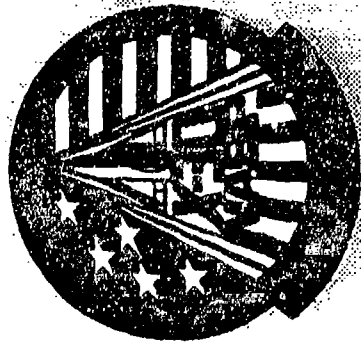


Source: Maglieri, 1991



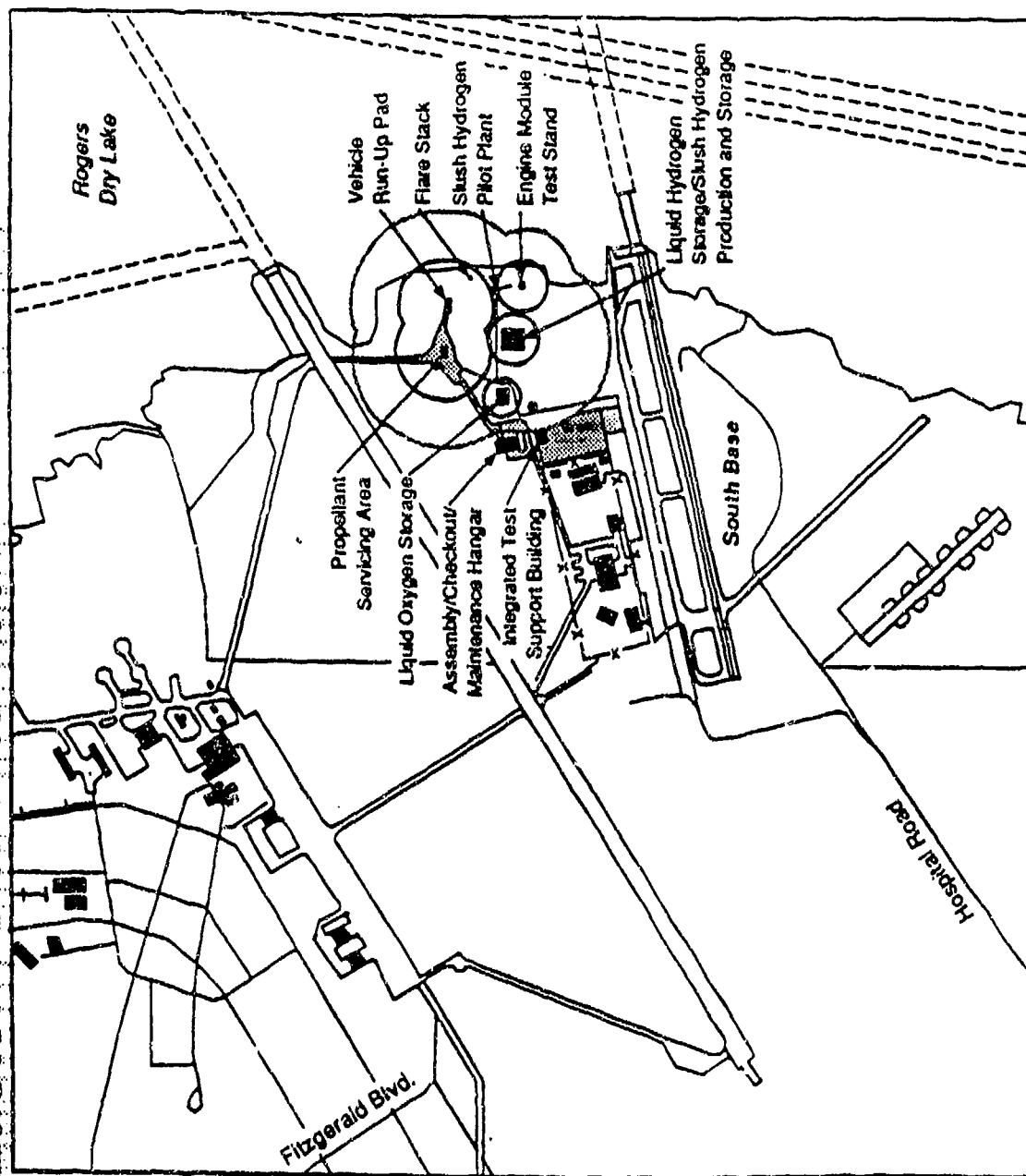
Edwards AFB, California Vicinity Map





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Eastern Site Alternative: Edwards AFB



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Flight Test Operations: Ozone Depletion

Influenced by exhaust products, trajectory, velocity, and duration

Complex analysis with several methodologies still being improved

Primary exhaust products are:

- Nitrogen (N_2 from Airbreathing Engines)
- Water (from Hydrogen/Oxygen Combustion)
- Very small quantities (<5%) of H_2 , O_2 , H , O , OH , NO , and NO_2

H_2O stratospheric properties

- Lingers in stratosphere
- Ice crystals may serve as buffer for ozone depleting chemicals

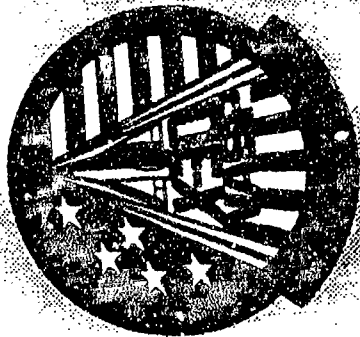
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***Flight Test Operations:
Ozone Depletion (Cont'd)***

For entire test program, environmental studies conclude:

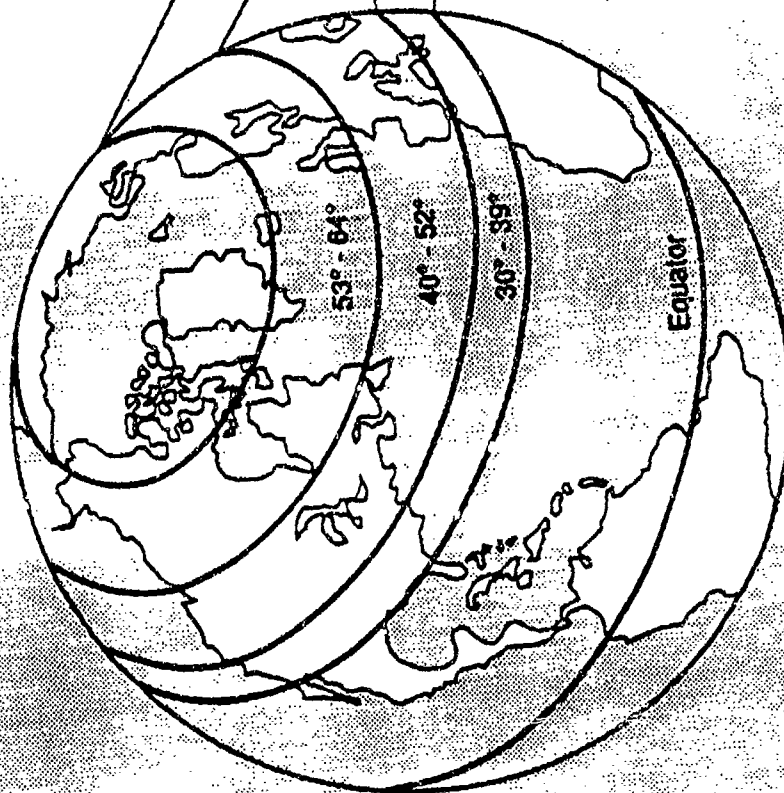
- 0.006% maximum local ozone depletion over United States
- 0.00009% maximum yearly average global total depletion

Negligible Decrease in Ozone Concentration



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Estimated Changes in Total Ozone in Northern Hemisphere, 1969-88



Average % Change 1969-1986	Winter Change	Summer Change
-2.3%	-6.2%	+0.4%
-3.0%	-4.7%	-2.1%
-1.7%	-2.3%	-1.9%
NASP projections: Less than 0.006%		

Source: Office of Technology Assessment, 1991.

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Flight Test Operations: Public Health and Safety

Primary flight concerns:

- High risk nature of flight program
- Exposure to hazards/hazardous materials

Environmental studies conclude:

- Minimal likelihood of flight accidents
- Depending on severity of potential accident, public health and safety effects could be minimal to severe
- Exposure to hazardous materials unlikely

Negligible Health and Safety Impacts

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Ground Support Operations ***(Generic Considerations)***

Ground disturbance

- Ground support site requires:
 - Approximately 130 acres for facilities
 - Approximately 400 acres for safety buffer zones
- Site must be available near existing airfield or sufficient site space for new airfield
 - 15,000 x 300 ft. runway (NASP)

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***Ground Support Operations
(Generic Considerations) (Cont.)***

Threatened and Endangered (T & E) species/sensitive habitats

- Construction could impact T & E species
- Construction could impact sensitive habitats
- Operations may cause other impacts
- Mitigation measures can reduce levels of impacts

Cultural resources

- Construction can impact cultural sites
- Mitigation measures can reduce levels of impacts

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Ground Support Operations (Cont.)
(Generic Considerations)

Air quality

- Construction, traffic, and operations: small amounts of emissions
- Ground-disturbing activities: short-term elevations in particulate matter levels
- Emissions may be important in non-attainment areas

Geology and soils

Construction activities can cause:

- Construction activities
 - Soil erosion
 - Loss of prime and unique farmland
 - Loss of mineral/aggregate resources
- Mitigation measures can reduce impacts

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Ground Support Operations (Generic Considerations) (Cont.)

Water use

- Additional personnel increases will increase water use
- Can be important in areas of low water availability
- Mitigation measures can reduce impacts

Noise

- Engine testing can cause high level noise
- Mitigation measures can reduce impacts

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Positive Environmental Contributions of NASP Program

Continued research into liquid hydrogen contributes to national transition away from fossil fuels

- Cleaner burning fuels
- Viable alternatives for space launch propellants

CFD codes are being used to reduce auto emissions

Developed new environmental modeling techniques for hypersonic programs

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Positive Environmental Contributions of NASP-like Aircraft

No A1, HCL, or CO₂ exhaust products

No ocean pollution or debris from staging

NASP may be used for:

- High altitude stratospheric data collection/research
- Sonic boom data collection/research

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Environmental Management Considerations

Technical support team

- Hire top industry experts to perform environmental analysis

Legal requirements

- Focus resources on environmental drivers
- A court injunction can freeze the program

Don't re-invent the wheel

- Large amounts of data already available
- Consult with similar programs and other programs at the same location

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Environmental Management Considerations (Cont'd)

Consult early

- Hold scoping meetings when program plan is defined
- Consult with local and regional government agencies

Develop realistic EIS budget

- Additional studies may result from public hearings (from Draft EIS)
- Need plan and funds to perform accepted mitigation measures

Environmental Study
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Future Plans

NASP environmental analysis on hold

Update analysis when appropriate

Continue interaction with applicable agencies to develop mitigation measures

Continue interaction with applicable agencies to develop mitigation measures

- California State Historic Preservation
- National Council of SHPO's
- National Council on Historic Preservation
- Advisory Council on Historic Preservation
- U.S. Fish & Wildlife Service

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Conclusion

No environmental show stoppers

**NASP program is generating environmental analyses for
future hypersonic programs**